TACTILE OUTPUT DEVICE

FIELD OF THE INVENTION

[0001] This invention relates generally to output devices, and more particularly to tactile output devices.

BACKGROUND OF THE INVENTION

[0002] Most graphic output to users is via a display unit. The display can be two-dimensional, and less frequently, three-dimensional. The assumption is that most users can view the display.

[0003] However, there are a number of situations where this assumption is wrong. In some situations, the user's visual system is otherwise occupied on more important tasks, such as navigation or tending to dangerous equipment. Other situations might preclude the installation of a display unit in the user's line of sight. Some users may be physically impaired to the extent that it is difficult or impossible for them to use a display unit.

[0004] Therefore, tactile output devices have been developed. The most common type of tactile output device is a Braille reader, see U.S. Pat. No. 6,255,938, "Device for the input and read-out of data," issued to Bornschein on Jul. 3, 2001. That type of device uses mechanical pins and is limited in that it can only convert text to tactile output.

[0005] Another type of device converts images to tactile output, see U.S. Pat. No. 6,703,924 "Tactile display apparatus," issued to Tecu et al. on Mar. 9 2004. That device includes an array of electro-mechanical output elements, with each element corresponding to at least one pixel in an image. The elements are in the form of movable pins coupled to linear stepping motors.

[0006] Most prior art tactile output device use pins and are activated using electro-mechanical components. There are a number of problems with such devices. They are relatively complex, expensive to manufacture, heavy, require considerable power, and subject to latency. Portability is a serious concern.

[0007] Therefore, it is desired to provide a tactile output device that overcomes the limitations of the prior art.

SUMMARY OF THE INVENTION

[0008] The embodiments of the invention provide a tactile output device capable of rendering images as three dimensional contours. Such a device can be used in conjunction with front- or rear-projected visual display elements to achieve tactile interaction with computers, displays, appliances and other devices. The device allows for relief rendering by means of an electro-active polymer film that is locally activated to generate a sensation of a raised tactile pixel. Such elementary tactile elements can be further combined into continuous surface relief that can be sensed by touch.

[0009] The tactile output device includes an electro-active polymer layer, and first and second sets of coplanar conductors arranged proximate to the layer. The first and second sets of conductors are approximately at right angles to each other, and the conductors within each set are spaced apart and parallel to each other. The conductors can be selected individually to convey current to expand and contract the electro-active polymer in vicinities where the conductors intersect. The selection can be according to pixels in an image to produce a three-dimensional contoured surface corresponding to the image.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. **1** is an isomeric view of a tactile output device according to an embodiment of the invention;

[0011] FIG. **2** is a top view of the device of FIG. **1**;

[0012] FIG. **3** is a block diagram of a system incorporating the device of FIG. **1**;

[0013] FIG. **4** is a side view of the device of FIG. **1** with two layers; and

[0014] FIG. **5** is a view of the device of FIG. **1** with embedded conductors.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0015] FIGS. **1**, **2**, **4** and **5** show a tactile output device **10** according to an embodiment of the invention, not to scale. The device includes an electro-active polymer layer **100**, see below.

[0016] One set of conductors **101** are arranged on one side to the layer, and another set of conductors **102** are arranged on another side of the layer. The conductors in each set are spaced apart and parallel to each other. The sets **101** and **102** are at right angles to each other. The conductors in each set are coplanar with the layer. It should also be understood that the conductors can be embedded in the layer, see FIG. **5**. The conductors can be cylindrical or rectangular in cross section. In a preferred embodiment, the conductors are deformable.

[0017] As shown in FIG. **2** when viewed vertically, the conductors **101**-**102** intersect each other at and array of points **103**. Because of the above arrangement of the conductors, the points form an array, e.g., the array can be regular or irregular. The conductors are individually addressable, similar to the way pixels are addressed on a visual display. The points **103** correspond to a pixel array in an output relief image.

[0018] Depending on current applied to a selected pair of conductors, the polymer layer at the point of intersection of the conductors can expand of contract. The amount of expansion or contraction can be controlled by the amount of current. The polymer can expand by as much as a factor of three in terms of volume. The force exerted can be up to 100 N/cm^2.

[0019] Thus, during operation, the layer **100** has a tactile texture. Tactile texture is the actual (3D) feel of a surface. Tactile texture can be rough, smooth, thick, thin, sandy, soft, hard, warty, coarse, fine, regular or irregular, and moving.

[0020] The tactile output device **10** can be incorporated into a graphic output system as shown in FIG. **3**. A graphic application **300**, provides output to a rendering unit **310**, which in turn drives a conventional graphic processing unit (GPU) **320**. Instead of being connected to a display unit, the GPU is connected to a tactile controller **330**. The controller provides address decoding and current drivers for the conductors **101**-**102** of the tactile output device **10**.

[0021] In an alternative embodiment, as shown in FIG. **3**, the controller **330** can also be coupled to a frame buffer and a visual display device **340**. It should be noted that the resolution of the grid points does not need to correspond exactly to the resolution of the image pixels, it can be greater of less.

[0022] It should be understood that the device **10** can be interfaced to any system that generates images, including a sequence of image (video).